

## **CONVERSION OF SINGLE PHASE TO MULTIPLE PHASE ALTERNATING CURRENT**

### **BACKGROUND OF THE INVENTION**

- [1] This invention relates to a method and apparatus for utilizing a forty-two volt (42 V) power distribution system (42 V alternator, 36 V battery) to control multiple vehicle motors by converting single phase alternating current to three-phase alternating current.
- [2] As more electrically controlled devices are incorporated into vehicles, the power supply for running these devices must also be increased. The standard twelve volt (12V) battery with a fourteen volt (14V) alternator that has traditionally been installed within the vehicle does not provide sufficient power to meet the increased demands.
- [3] To meet the demand for an increased power supply, the automotive industry is moving towards a thirty-six volt (36V) / forty-two volt (42V) alternator system. As this transition is made, hybrid systems that can support both voltages are needed. These hybrid systems are referred to as a twelve volt (12V) / thirty-six volt (36V) battery power distribution system or a fourteen volt (14V) / forty-two volt (42V) power distribution system. The use of a 36V/42V system permits the use of electrical components that could not previously be used in 12V/14V systems. The 36V/42V system provides direct current (DC) to power DC motors that run the various vehicle actuation systems such as window regulators, sunroofs, power locks, power mirrors, power seats, etc.

[4] In a 36V/42V power system, there is sufficient power to use alternating current (AC) induction motors for running the various actuation systems in a vehicle. AC induction motors require at least single-phase AC power (for single-phase induction motors); however, to operate efficiently and smoothly, three-phase AC power is preferred (for three-phase induction motors). Thus, the use of AC induction motors requires conversion of the direct current power supply to three-phase alternating current. Typically, direct current is converted to three-phase alternating current by at least six (6) power switches and multiple wires leading into the power converter. This requires a complex circuit that is expensive.

[5] On the other hand, conversion of direct current into single-phase alternating current can be performed simply by two (2) power switches. Thus it is desirable to provide a low-cost method and apparatus for converting single phase alternating current to three-phase alternating current to power induction motors without additional power switches.

#### **SUMMARY OF THE INVENTION**

[6] A system for converting single phase alternating current produced by pulse width modulation to three-phase alternating current, uses lead/lag circuits to produce the phase shifts. The direct current source is provided by a twelve volt (12V) / thirty-six volt (36V) power distribution systems. This configuration permits the use of induction motors for operating vehicle systems such as power seats, power windows, door locks, etc., for example. Induction motors increase reliability and accuracy for overall improved system performance.

[7] The method for converting single phase alternating current to multiple phase alternating current to simultaneously power multiple vehicle systems includes the following steps. Single phase alternating current is produced from a direct current source with pulse width modulation. The single phase alternating current is split into a plurality of separate paths including at least a first path, a second path, and a third path. The phase of the alternating current on the second path is shifted to a different phase than the phase of the first path. The phase of the alternating current on the third path is shifted to a different phase than the phase first or second paths to create three-phase alternating current power. Multiple vehicle systems are operated by the three-phase alternating current power.

[8] In a disclosed embodiment of this invention, the system for converting single phase alternating current to multiple phase alternating current to simultaneously power multiple vehicle systems includes a direct current source and a single pulse width modulation generator for converting direct current to alternating current. This provides one power supply path of alternating current having a first phase. A splitter splits the one power supply path of alternating current into a plurality of power supply paths including at least a first power supply path, a second power supply path, and a third power supply path. At least one lead/lag circuit shifts the alternating current of the second path to a second phase different than the first phase of the first power supply path and at least one lead/lag circuit shifts the alternating current of the third path to a third phase different than the first phase or the second phase. A plurality of induction motors operates multiple vehicle systems via a three-phase alternating current power comprised of the first, second, and third paths.

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[9] This configuration provides a simplified and inexpensive means of converting direct current from a 36V power supply to three-phase alternating current power for operating induction motors. The induction motors operate efficiently and reliably to improve the performance of the respective vehicle system.

[10] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[11] Figure 1 is a schematic diagram incorporating the subject invention.

[12] Figure 2 is a schematic diagram depicting one embodiment of the invention incorporated into a vehicle system.

#### **DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT**

[13] A system for converting single phase alternating current into three-phase alternating current is shown schematically at 10 in Figure 1. The system 10 has a twelve volt (12V) / thirty-six volt (36V) battery power distribution system 14. The operation of batteries is well known in the art and thus will not be discussed in detail. The system 10 provides 12V power for vehicle operations that have traditionally required 12V power and provides 36V power for additional vehicle systems that require more power to operate accurately and efficiently. The 12V / 36V system provides direct current (DC) that is converted to alternating current (AC) to power induction motors 16 that run various vehicle operating systems 18 such as window regulators, sunroofs, power locks, power mirrors, power seats, etc., for example.

[14] A converter 20 comprised of a pulse width modulation (PWM) generator produces single phase alternating current 22 from the direct current source 14. A splitter 24 splits the single phase alternating current 22 into a plurality of separate alternating current paths including a first path 26a, a second path 26b, and a third path 26c. The first path 26a has a first phase 28 that is equivalent to the single phase alternating current 22. The second path 26b is shifted to a second phase 30 of alternating current that is different than the first phase 28. The third path 26c is shifted to a third phase 32 of alternating current that is different than the first 28 or second 30 phases. This creates three-phase alternating current power 34 that is used to operate induction motors 16 for the multiple vehicle systems 18.

[15] The shifting of the second 30 and third 32 phases is accomplished with analog lead/lag circuits 36. The operation of lead lag circuits is well known. In one embodiment, shown in Figure 2, the single phase alternating current 22 is provided by a single wire that is tapped into at three (3) different locations. A first tap 38 is made into the single wire before phase shifting occurs, a second tap 40 occurs after the first phase shift, and a third tap 42 occurs after the second phase shift. The phase shifts are initiated by inductors 44 placed between the first 38 and second 40 taps and between the second 40 and third 42 taps. The inductors 44 create a time delay between the currents at each location, which results in the subsequent phase shift. The three-phase alternating current 34 is then supplied to the induction motor 16 to run the appropriate vehicle system 18.

[16] Preferably, the second phase 30 is shifted by approximately one hundred and twenty degrees (120°) compared to the first phase 28 and the third phase 32 is shifted

by approximately one hundred and twenty degrees ( $120^\circ$ ) compared to the second phase 30. In the preferred embodiment, the first phase 28 is maintained at approximately a zero degrees ( $0^\circ$ ) phase shift, the second phase 30 is maintained at approximately a one hundred and twenty degrees ( $120^\circ$ ) phase shift, and the third phase 32 is maintained at approximately a two hundred and forty degrees ( $240^\circ$ ) phase shift.

[17] By generating only a single phase alternating current by pulse width modulation and converting the single phase into a three-phase alternating current, the number of wires leading out of the power converter is significantly reduced. Further, the number of for power switches is minimized. This significantly reduces the cost and makes the use of induction motors for operating vehicle systems much more economical.

[18] Although a preferred embodiment of this invention has been disclosed, it should be understood that a worker of ordinary skill in the art would recognize many modifications come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.